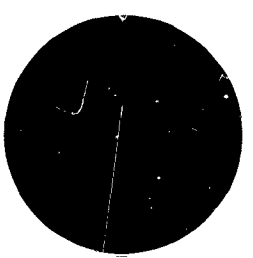
63-3-2

IBM RESEARCH

BEHAVIORISTIC OR NORMATIVE DECISION CRITERIA

Martin Shubik



RC 902

March 19, 1963

LIMITED DISTRIBUTION NOTICE

This report has been submitted for publication elsewhere and has been issued as a Research Paper for early dissemination of its contents. As a courtesy to the intended publisher, it should not be widely distributed until after the date of outside publication.

PRINTED IN U. S. A.

BEHAVIORISTIC OR NORMATIVE DECISION CRITERIA*

by

Martin Shubik

International Business Machines Corporation
Thomas J. Watson Research Center
Yorktown Heights, New York

ABSTRACT: Different models of decision making processes are discussed and contrasted. It is pointed out that the difference between certain "rationalistic" models and heuristic decision rules is more a matter of the scope of the process being modeled than a basic difference in approach.

* This research was supported in part by the Office of Naval Research under Contract No. Nonr 3175(00), NR 047040.

Research Paper
RC-902
March 19, 1963

1. GENERAL DISCUSSION

During the past thirty years, a growing dissatisfaction with microeconomic theory combined with an interest in and a need for understanding decision making in the firm and in other aspects of economic life has produced several apparently distinct schools of thought.

The pure economic theorist and mathematical economist may be contrasted with the planners and practising consultants and the new breed of behavioral scientists concerned with the explicit introduction of psychological and sociological variables into their models of economic man. The difference is most marked in the treatment and the discussion of the relevance of new versus old variables, but beyond this, all have become acutely aware of the stringent limitations on the use of simple models of "rational man".

In all newly developing areas of substantive knowledge there is always a clash between the analytical and the synthetical approach. The far-roving social scientist searching and conjecturing with little formal validation of his conjectures striving to devise methods to portray the gestalt of his subject is often constrasted with the analyst concerned with details, well-defined axioms, painstaking validation, and manipulation of closed and consistent formal models. Along with this contrast goes the belief that the more "conversational" of the behavioral scientists are necessarily less scientific than their matrix-inverting bretheren. This type of attitude is particularly true of

engineers, physicists, mathematicians addressing problems in the behavioral sciences for the first time.

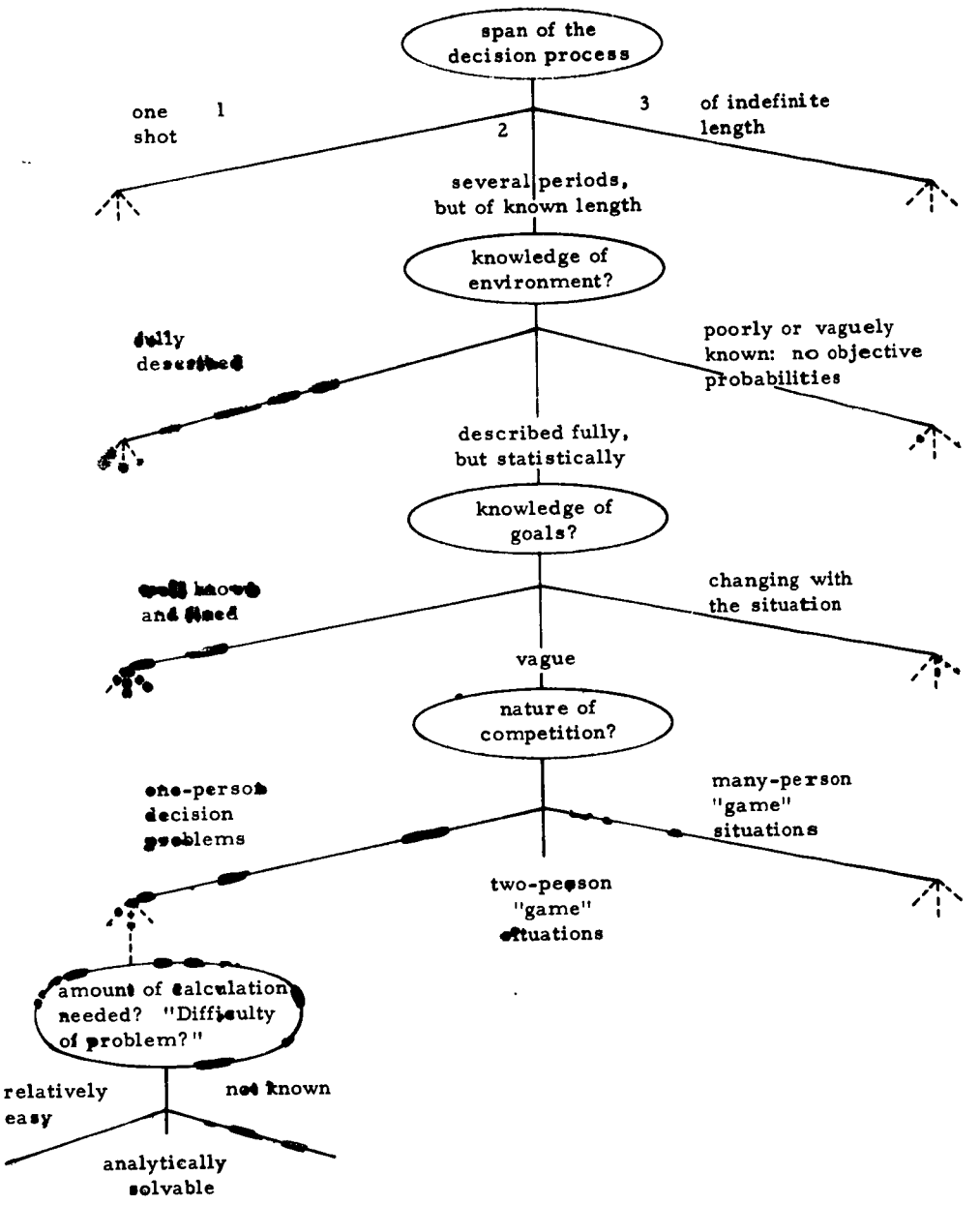
This brief paper is directed towards pointing out the dangers in allowing a false contrast to obscure the need for concerted verbal and mathematical or other formal approaches to the study of decision-making. At this juncture in our knowledge, it becomes highly important to blend institutional knowledge and mathematical ability—to utilize and formalize the uncommon, common sense of the practitioner and expert. Given the current state of our knowledge, for many good reasons, there is no one successful general theory of decision-making. The austere and elegant structure of parts of economic theory, statistics, game theory, learning theory and other parts of psychology is good and valuable in as far as it goes; however, in comparison to the structure of many branches of physics, it does not go very far. Both the methods for observation and the application of mathematical methodology are in their early stages at this time. The developments of economics and other behavioral sciences are important to laying the foundations for the several theories of decision-making which may at some later date, after they have proved successful, be combined into a more general theory.

A tree diagram given below serves to characterize some of the major considerations in describing the individual decision maker.

They involve assumptions about the environment, the goals, the nature of competition, the span of time over which decisions are to be made and the intelligence, rationality and other socio-psychological features of the individual.

Most economic theories of decision making regard errors in computation; blunders due to misperception or other erratic behavior as minor details to be accounted for in modifications of a theory based on homo oeconomicus. In military problems, however, we cannot dismiss the actions of the moron or the madman with such ease. Furthermore, the sociologists, anthropologists and psychiatrists have pointed out that an apparently standard "rational" economic norm in one society may be given a completely different interpretation elsewhere. The American efficiency expert entering an English or a Japanese factory will find himself confronted with a host of problems not relevant to "rational" decision-making at home.

At this point, as a crude approximation, we take the social and psychological aspects of the individual as given.


span of the decision process
one shot
1
2
3
of indefinite length
several periods, but of known length
knowledge of environment?
fully described
poorly or vaguely known: no objective probabilities
described fully, but statistically
knowledge of goals?
changing with the situation
vague
nature of competition?
one-person decision problems
many-person "game" situations
two-person "game" situations
amount of calculation needed? "Difficulty of problem?"
relatively easy
not known
analytically solvable

The very crude set of trichotomies presented above provides 3^5 categories which are, for the most part, significantly different and are relevant to various facets of human affairs.

Harking back to our concern with microeconomic theory, where is our utilitarian man? He is to be found in categories (1, 1, 1, 1, 1) or (2, 1, 1, 1, 1) where the first number refers to the first, second, or third branch of the tree, and so forth. Thus, the first array refers to the individual who knows his environment, has one choice to make, knows what he wants, is not involved with others in his choice, and faces a problem that he can solve in the time available.

(1, 1, 1, 1, 2) represents the type of situation in which techniques such as linear programming have been successful. If you happen to face a moderate sized travelling salesman problem and know what the solution is worth, it belongs here.

If the travelling salesman problem is made too large, or if we are confronted with chess, we come to (1, 1, 1, 1, 3) where our current state of the art calls for "heuristics" or high-class rules-of-thumb.

Quality control, some of the simpler problems in inventory control and sequential decision making have been successfully dealt with in (2, 2, 1, 1, 2).

Weapons evaluation and some relatively simple tactical

problems have been dealt with by two-person zero-sum game theory, best characterized in (1, 2, 1, 2, 2).

Unfortunately, many of the basic problems of economic competition, military, diplomatic or political affairs and indeed life in general belong to categories such as (3, 3, 3, 3, 3) or (3, 3, 2, 3, 3). It is equally foolish to belittle our achievments in handling a few of the simpler categories as it is to pretend that simple modifications of current theory will suffice to deal with the other situations.

Faced with the complexities encountered in an attempt to study decision-processes, we may adopt a behavioristic or a normative approach. We may concentrate on trying to describe how individuals behave or may addresss ourselves to the problem of advising them how they should behave. Even with the side-stepping of the ethical problems concerning normative theories, we are still confronted with many difficulties in description and prescription which illustrate that the distance between a behavioral approach and a normative one is by no means as far as it may seem to be.

An important example illustrating the difficulties of formulation of theory in the early stages in the development of a body of knowledge is provided by the various so-called theories for the solution to an n-person non-constant sum game. There is no single dominant theory which is accepted either as a normative proposition instructing

individuals how they should play, nor is there one accepted theory based on the description of how individuals do play. Under varying circumstances, a case may be made out for the von Neumann-Morgenstern stable sets 1/ the Shapley value 2/; the Harsanyi value 3/; the Nash non-cooperative equilibrium solution 4/; the Aumann-Maschler bargaining sets 5/; the "best-the-average" solution or many others.

A certain amount of experimental evidence exists for several of the solutions. For instance, the Nash non-cooperative equilibrium solution appears to serve as a fair predictor in some experiments in which there is no face-to-face communication between the players 6/. Other experiments have shown that under the appropriate circumstances, the Shapley value 7/ provides predictions, and that in certain simple situations the outcomes of bargaining processes lie in the Aumann-Maschler bargaining sets.

Where do these various theories of solution to games come from? Are they behavioristic or normative? Why are they unsatisfactory? Writers of theory do not start with a tabula rasa; some have had experience as practitioners, others have watched the processes of their interest for many years prior to the development of the theories; still others, without explicit knowledge of the processes discussed in their theories bring to their assumptions a host of implicitly absorbed

observations and conditioned experiences. Thus, when we examine even the apparently most simon pure assumptions or axioms upon which a solution concept may be based; whether it is in reference to a bargaining process, an arbitration scheme or an individual grappling with uncertainty, the antiseptic appearance of the mathematical axioms belies the vast array of implicit assumptions concerning how individuals do and should behave.

For example, the mathematical-economic models of maximizing utilitarian man may formally reflect Marshall's theory of the firm and industry. Mathematically they are neat and not very complex; and when stated merely as mathematical abstractions they hide the richness of the observations, commentaries and qualifications with which Marshall accompanied them. His comments provided the justification for using the abstractions to study the processes of the politico-socio-economy in which he dwelt. The generality of an unqualified mathematisation of Marshall's theory is misleading in the extreme.

The theory of games was singled out above, to provide examples of the difficulty in theory building. We equally as well could have selected subjective probability; or "satisficing" or aspiration, or learning, or organization. In all of these, the assumptions, the axioms, observations, theories and so-called theories offer a blend of normative and behavioristic rules; in some situations the distinction

between the normative and behavioristic theories is clear-cut. For example when an individual is confronted with a known set of outcomes for which he has specific values we may say (tautologically) that he should select the alternative which leads to the outcome with greatest value. We may then, as in the case of linear programming, supply an algorithm to select the appropriate alternative. In the same situation, we may still show experimentally that the individual has specific values for outcomes, but our observations of behavior show that he does not select the best alternatives. In various suggested theories of arbitration, the distinction between normative and descriptive is not so clear. Is the axiom of symmetry based upon a belief that people should follow it, or is it based upon observations, cultural training or folklore that this is what is accepted in a given society?

2. SOME RULES FOR BEHAVIOR

Economic man tells us how to act in simple situations where we know what we want and can calculate how to get it. If we are in conflict or doubt, he is of little use. If there is a conflict involving pure opposition between individuals who know what they want, the theory for the solution to two-person zero-sum games provides a persuasive recommendation in maximim behavior. However, even for a game as simple as chess, the theory does not tell the individual

how to make his moves.

When the environment is unknown, there have been many suggestions as to how the individual should account for uncertainty. Milnor has presented an excellent summary and analysis of the axiom systems underlying several ways in which uncertainty may be taken into account 8/. None of them are entirely satisfactory as normative prescriptions inasmuch as examples can be constructed which are not resolved by the different methods in a manner that coincides with intuition or observation. Raiffa and Schlaifer 9/ in their development of a decision theory have stressed the importance of the use of subjective probability as a way for utilizing the understanding and knowledge of the expert, the actual decision-maker steeped in the details and special perceptions of his art.

We have already noted that when the environment involves explicit interaction with other humans or human agencies, there exists a host of solution concepts for n-person games, none of which is entirely satisfactory either as normative prescription or behavioral description. When lack of knowledge concerning the environment, combined with inability to calculate the consequences of all but a few simple courses of action is added to the decision problem, our "theories" are in even poorer condition. The broad area of artificial intelligence 10/ is addressed to providing algorithms to deal with

decision processes where exhaustive exploration of alternatives is not possible and where no analytical methods are known.

An intermix of work with computers, psychology, statistics, and other disciplines has yielded several suggestions and observations for decision-making. Simon and his associates at Carnegie have attempted to define a satisficing man [1]. An organization of "satisficing individuals" displays an adaptively rational behavior characterized by processes for:

(1) The quasi-resolution of conflict

(2) Uncertainty avoidance

(3) Problemistic search

(4) Organizational learning.

For example, the firm is regarded as an organization with several decision centers; its goals are influenced by experience which modifies the aspiration levels of its members. The firm attempts to avoid uncertainty; hence, there is an emphasis on short term correction plans to deal with the immediate future and short run feedback, rather than long run anticipation. Plans, standard operating procedures and tradition are all used as mechanisms to dampen the degree of uncertainty. Stress is laid on the proposition that the natural language to discuss adaptive behavior is in terms of programming.

There has been a moderate success in simulating the behavior

of middle and lower middle management.

Although uncertainty avoidance is suggested as a natural part of organizational behavior, there are two very different and highly interrelated types of uncertainty. An individual may be uncertain about the outcome of an action and may be uncertain about the value of an outcome. Major decisions are often not marginal decisions. A president of a large mining company recently speaking to a group of professors concerned with management science commented that there was a rule in mining which suggested that no property which could not show a profit, even with mismanagement, should be worked. If an investment is in doubt, there is the choice between performing a more careful calculation or offering to buy the investment for less than is being asked. In the second case, uncertainty of outcome is increased and uncertainty of valuation is decreased. An offer of a lower price may increase the possibility that the seller will refuse to sell the investment; buying at a lower price increases the chance that it will be a good investment regardless of the vagaries of the market.

A simple analogy is provided by a firm with limited capacity being confronted with more potential jobs than it can handle. If there are n jobs and the probability of obtaining the i^{th} job depends upon p_i, then if the firm has a capacity of k less than n, its optimal policy will be to make its prices sufficiently high that it loses an appropriate

number of jobs.

Siegal 12/ and others have suggested an "aspiration level" approach to decision-making. The level of aspiration is originally defined and measured in much the same way as von Neumann-Morgenstern utility. However, over the course of time, individuals are regarded as lowering or increasing their sights. Successive failures lower the aspiration level, success raises it. The behavior of Robert Bruce, Dick Whittington and others who follow the rule of fortiter in adversitas does not fit into the aspiration model.

Festinger 13/ has performed experiments to prove the value of his concept of "cognative dissonance". According to this view, further off fields are not greener and grapes out of reach are indeed more sour than grapes which can be plucked. These observations suggest that individuals in order to reach a decision and justify it to themselves change their values to conform to the possibilities. "Come the Revolution, we will all have strawberries and cream for breakfast, and everyone will like it".

In summary we note that:

Economic man knows his choices, values, and the outcomes; he selects from his known world.

Economic-Decision theory man removes his uncertainties by introducing subjective probabilities into his rational calculations.

Aspiring man moves with the flow of affairs. If he is successful, he wants more; if he fails, he wants less.

Festinger's man conforms more to the type of individual confronted on every other page of Alice-in-Wonderland. He changes his values in order to justify his decision.

The investing man changes the odds on the prospects with which he is confronted in order to both clarify their worth and cut down on the amount of decision-making required.

In my opinion, the time for synthesis of decision theories is not yet with us. Many of the normative and behavioristic schemes are of worth in a limited context. However, for more detailed formulation, testing and experimentation is needed. Our theories may aid in some economic and military situations. But even so, except as aids to clear thought on subjects such as negotiations and threats during negotiations, little other value has been derived.

As a final example, a simple unsolved problem is posed. It is unsolved in the sense that there are several normative decision criteria which have been suggested as well as several behavioristic ones. It is possible to obtain virtually any outcome as a point which satisfies some of the theories.

The example is the prisoners' dilemma game iterated indefinately with a discount rate included. Suppose two players play the

following game every period:

	1	2
1	10, 10	-10, 15
2	15, -10	0, 0

In the one-period game, considerations of individual rationality call for them to play (2, 2) and obtain (0, 0). If the game has no definite end, and there is a discount rate p, then the long run payoff to player i is:

$$\Pi_i = \sum_{t=0}^{\infty} \rho^t \Pi_{i,t}.$$

If either player were to use a "threat" strategy such as: "Play 1 as long as 1 is observed; if ever 2 is observed, play 2 from then on." This would make (1, 1) an equilibrium point. Is it reasonable, however, to believe that for a one period departure from grace, one individual will punish another from that point on at great cost to himself? Formally, there are many extensive form strategies containing threats which apparently enable almost any outcome to be enforced in an equilibriu. In a broad sense, they are not all equally plausible.

The normative suggestion that the players should maximize jointly has them playing (1, 1); the naive extension of the non-cooperative equilibrium concept to games of indefinite length turns almost anything into an equilibrium point. The theory we need, we do not have yet. It must take into account both the players' innate desires to cooperate and the intelligence, perceptions, and other abilities in communicating with each other and inferring from each others' behavior.

REFERENCES

1. von Neumann, J. and Morgenstern, O.: Theory of Games and Economic Behavior, Princeton: Princeton University Press, Third Edition, 1953.

2. Shapley, L. S.: "A Value for n-Person Games", Contributions to the Theory of Games, II, Princeton, 1953, pp. 307-318.

3. Harsanyi, J.: "Measurement of Social Power in n-Person Reciprocal Power Situations", Behavioral Science, 7, 1, January 1962, pp. 81-91.

4. Nash, J. F.: "Non-Cooperative Games", Annals of Mathematics (2), 54, 1951, pp. 286-295.

5. Aumann, R. J. and Maschler, M.: "The Bargaining Set for Cooperative Games", Contributions to the Theory of Games, V, Princeton, (Forthcoming, 1963).

6. Shubik, M.: "Some Experimental Non-Zero Sum Games with Lack of Information About the Rules", Management Science, 8, 2, January 1962, pp. 215-234.

7. Kalisch, G. K., Milnor, J. W., Nash, J. F., and Nering, E. D.: "Some Experimental n-Person Games", Decision Processes, New York: Wiley, 1954, pp. 301-327.

8. Milnor, J.: "Games Against Nature", Decision Processes, New York: Wiley, 1954, pp. 49-68.

9. Raiffa, H. and Schlaifer, R.: Applied Statistical Decision Theory, Harvard, 1961.

10. Minsky, M.: "Artificial Intelligence", Proceedings of the IRE, January 1961.

11. Cyert, R. M. and March, J. G.: "The Behavioral Theory of the Firm, A Behavioral Science-Economics Analysis", Pittsburgh (mimeographed), 1962.

12. Siegel, S.: "Level of Aspiration and Decision Making", Psychological Review, 64, 4, 1957, pp. 253-262.

13. Festinger, L.: "A Theory of Cognative Dissonance", Second Edition, Stanford University Press, 1961.